



The NPOESS Aerosol Polarimetry Sensor

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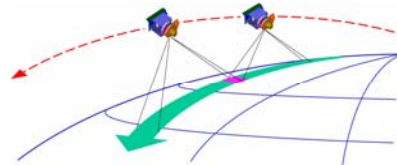
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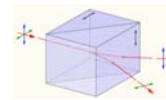
- Atmospheric aerosol particles directly impact the earth's radiation balance by reflecting and absorbing the incident solar radiation.
 - This cools the earth's surface and atmosphere below the aerosols by reducing the incident sunlight, and locally heats the atmosphere surrounding the aerosols
- The aerosols also indirectly affect the climate by altering the clouds.
 - They can increase the cloud albedo by distributing the cloud liquid water among more smaller droplets
 - They can increase the cloud lifetime because the smaller droplets reduce the rainfall
- While the aerosol effects on climate forcing are smaller than those due to greenhouse gases, the uncertainties in these direct & indirect effects by the atmospheric aerosols represent two of the largest potential sources of error in climate models.



Along-track scanning photopolarimeter. By scanning along the ground track, the instrument observes the same piece of real estate from different viewing directions, thereby providing multiple measurements of the reflected radiance and polarization

The APS instrument determines the Stokes Parameters using pairs of Wollaston Prisms (which separate the incident light into its orthogonally polarized components), to obtain redundant measurements of I, Q, and U.

The circular polarization, V, provides little additional information on the atmospheric aerosols or cloud particles, so is not measured by the APS instrument.



- Nine spectral bands 400 to 2400 nm
 - 412, 488, 555, 672, 865, 910*, 1378, 1610, and 2250 nm
- Most are the same as VIIRS for synergy
 - This also allows the APS radiometer to be cross-calibrated with VIIRS
- One band (*) has been replaced to measure total column water
- The polarization is relatively insensitive to surface reflections, and provides additional information on the aerosol & cloud properties
- APS design traces directly back to the Research Scanning Polarimeter (RSP)
 - [Cairns et al. *Proc. SPIE*, **3745**, 186-196, 1999]
 - [Chowdhary et al. *J. Atmos. Sci.*, **62**, 1093-1117, 2005]

Objectives for APS EDRs

Parameter	Range	Accuracy	Precision	Stability
Aerosol Optical Thickness * (Oceans)	0.0 to 10.0	Greater of 0.01 or 5%	0.005	0.005
Aerosol Optical Thickness * (Land)	0.0 to 5.0	Greater of 0.03 or 7%	0.02	0.005
Aerosol Effective Radius *, r_{eff} [μm]	0 to 10	Greater of 0.05 or 5%	Greater of 0.05 or 5%	Greater of 0.05 or 5%
Aerosol Effective Variance *, v_{eff}	0 to 5	Greater of 0.2 or 30%	Greater of 0.1 or 20%	Greater of 0.1 or 20%
Refractive Index * (Real Part)	1.3 to 1.8	0.01	0.005	0.005
Single Scatter Albedo *	0 to 1	0.01	0.01	0.01
Cloud Particle Effective Radius, r_{eff} [μm]	0 to 80	Greater of 0.5 or 5%	Greater of 0.3 or 3%	Greater of 0.3 or 3%
Cloud Particle Effective Variance	0 to 2	Greater of 0.04 or 40%	Greater of 0.03 or 30%	Greater of 0.03 or 30%

* Aerosol parameters determined separately for accumulation and coarse particle size modes

The RSP airborne instrument, which is conceptually similar to the APS, has been developed and flown in a number of field campaigns, which provide a proof of concept for the APS. Some of these results are presented in the adjacent poster [p1.13]:
 "Using multi-angle, multispectral photo-polarimetry from the Aerosol Polarimetry Sensor to constrain optical properties of aerosols and clouds: Demonstration of capabilities using results from similar measurements in four field experiments"
 by Jacek Chowdhary, Brian Cairns, Michael I. Mishchenko, Larry D. Travis, Makoto Sato

A early flight of the APS instrument is planned as part of NASA's Glory Mission. More information on the Glory mission is available at:
<http://glory.giss.nasa.gov/>
 Also see Mishchenko et al., *JQSRT*, **88**, 149-162, 2004.

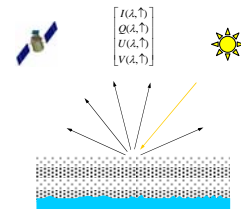
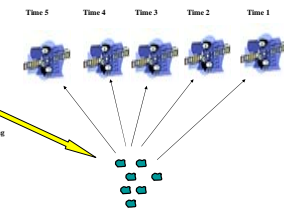
Acknowledgements – A large number of people have and are contributing to the development of the APS for NPOESS. These include: J.E. Hansen, J. Chowdhary (NASA/GISS); R. Burg, Y.J. Kaufman, J.V. Martins (NASA/GSFC); D. Anderson, R. Hooker, H. Maring, (NASA/Hq); V. Grano, J.M. Haas, J.L. Duda, J. Parsons, S. Mango (NPOESS/IPO); D. Nelson, C. Schuele (Raytheon/SBRS); S. Ubhayakar (NGST).

We thank these and all the other individuals who are helping develop the APS.

Threshold Requirements For APS EDRs

Parameter	Range	Accuracy	Precision	Stability
Aerosol Optical Thickness * (Oceans)	0.0 to 5.0	Greater of 0.02 or 7%	Greater of 0.01 or 5%	0.01
Aerosol Optical Thickness * (Land)	0.0 to 5.0	Greater of 0.04 or 10%	Greater of 0.03 or 7%	0.01
Aerosol Effective Radius *, r_{eff} [μm]	0 to 5	Greater of 0.1 or 10%	Greater of 0.05 or 10%	Greater of 0.05 or 10%
Aerosol Effective Variance *, v_{eff}	0 to 3	Greater of 0.3 or 50%	Greater of 0.1 or 40%	Greater of 0.2 or 40%
Refractive Index * (Real Part)	1.3 to 1.7	0.02	0.01	0.01
Single Scatter Albedo *	0 to 1	0.03	0.02	0.02
Water Cloud Optical Thickness	0 to 300	Greater of 0.1 or 8%	Greater of 0.1 or 8%	
Cloud Particle Effective Radius, r_{eff} [μm]	0 to 50	Greater of 1.0 or 10%	Greater of 0.5 or 5%	Greater of 0.5 or 5%
Cloud Particle Effective Variance	0 to 2	Greater of 0.05 or 50%	Greater of 0.04 or 40%	Greater of 0.04 or 40%

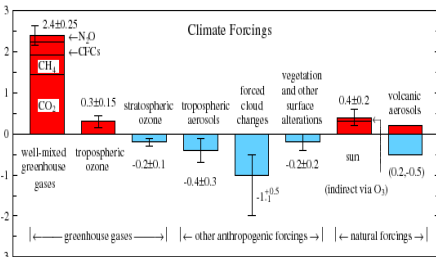
* Aerosol parameters determined separately for accumulation and coarse particle size modes



The satellite instruments measure various characteristics of the reflected sunlight. The Stokes parameters I, Q, U, and V of the reflected light vary with wavelength, λ , and scattering direction

$$\begin{aligned} I &= I_{tot} \\ Q &= I_0 - I_{90} \\ U &= I_{45} - I_{135} \\ V &= I_R - I_L \end{aligned}$$

where I_{tot} = intensity with no analyzer.
 I_0 = intensity with linear analyzer at 0°, 45°, 90°, and 135°.
 I_R = intensity with retarder fast axis at 45°, analyzer at 0°.
 I_L = intensity with retarder fast axis at -45°, analyzer at 0°



- The Aerosol Polarimetry Sensor (APS) instrument is being developed for the NPOESS to measure the properties of the atmospheric aerosols in sufficient detail and accuracy to help reduce these uncertainties in the climate forcing due to aerosol particles.
- The APS will be a high-precision multi-spectral photopolarimeter which will scan along the sub-orbital track as the satellite passes overhead providing multiple views of the each point along the ground track.
- The measurements will be made at 9 different wavelengths between 400 and 2400 nm, through pairs of Wollaston prism analyzers, which allow the simultaneous determination of the Stokes polarization parameters I, Q, and U.
- These measurements will be used to determine the aerosol optical thickness, the effective radius, and the effective variance for both the accumulation and coarse particle modes of a bimodal aerosol size distribution.
- The real part of the aerosol refractive index and the aerosol single-scattering albedo will also be produced along with a determination of whether or not the aerosol particles are spherical.
- NASA is planning an early flight for an APS instrument as part of the Glory Mission.
 - Their science requirements are essentially the same as the NPOESS requirements for the APS, and are discussed further by Mishchenko et al. [*JQSRT*, vol. 88, 149-161, 2004].